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THE SCENARIO OF PLANT GENETIC RESOURCES

C.R. BABU AND M.C. GOPINATHAN

Department of Botany, University of Delhi, Delhi

ABSTRACT

The economic and technological potentials, and conservation of vanishing genetic resources are discussed in the light of prevailing global ecological conditions with particular reference to tropics.

INTRODUCTION

As a result of the encroachment on natural ecosystems by human population growth and economic development, the biological diversity is threatened. The human populations consume directly and indirectly 40 % of the terrestrial net primary productivity. The tropical deforestation may lead to the potential imminent extinction of perhaps half the world's species — a loss that could equal some of the largest mass extinctions of the geological periods. The species extinction crisis is a threat to civilisation second only to the threat of thermonuclear war (Lewin, 1986). Consequently, the biodiversity has become hot topic of today.

The plant genetic resources is a category of genetic diversity (refers to variety of genes), and refers to the intra- and interspecific variation that has been, is being or is likely to be used in the selection or improvement of domesticates, or the manipulation and enhancement of wild stocks. In other words genetic resources can be defined as the genetic variation available for plant improvement to meet our needs in terms of particular products, increased efficiency, and higher levels of productivity (Peacock, 1984).

GENETIC RESOURCES AND CROP IMPROVEMENT

The technological revolution in farming methods coupled with the development of high-yielding hybrid crop varieties have, no doubt, increased the food production, and, thereby averted the calamity — the world running out of food (Brady, 1982). However, the success of new cultivars with the associated technologies and the thrust of green revolution are destroying the genetic variability which formed the very basis for the success of such programmes (Chang *et al.*, 1972; Galinat, 1972; Harlan, 1972, 1975; Wilkes & Wilkes, 1972). The genetic resources are also being lost by increased grazing, by abandonment of old farming systems and by other habitat pressures. All these factors have led to the genetic erosion or genetic wipe-out at three levels of biological diversity — species, genotype, and intragenotype, and will continue to destroy sources of as yet unknown but potentially valuable genes necessary for future crop improvement (Marshall, 1977; Timothy & Goodman, 1979).

The hazards of genetic homogeneity of modern agricultural plant communities grown as massive monotypic monocultures are : (i) the spectare of massive crop failures because of increased genetic vulnerability to diseases and pests (Wharton, 1969; Smith, 1971); (ii) the environmental pollution due to heavy use of pesticides, fungicides, and herbicides for sustaining high yields; (iii) the ecological disruption due to excessive use of pesticides and fungicides which result in the evolution of resistant strains of fungi, pests and insect vectors of human diseases (Chapin & Wasserstrom, 1981) and (iv) the decrease in future genetic gains by plant breeding owing to the use of genetically uniform cultivars as parents.

Recently there has been a spurt of studies, conferences and symposia on biological diversity, genetic vulnerability, narrowing of the gene base of important cultivars, loss of gene pools of both economic and wild species and the potential utility of genetic resources (Frankel & Bennett, 1970; Harlan, 1972, 1975; Nat. Acad. Sci., 1972, 1980; Frankel & Hawkes, 1975; Timothy & Goodman, 1979; Frankel & Soule, 1981; Walsh, 1981; Plucknett & Smith, 1982; Prescott-Allen & Prescott-Allen, 1983; Swaminathan, 1983; Plucknett *et al.*, 1983; Holden & Williams, 1984). These have emphasized the significance of gene pools of weedy and wild relatives of crop plants for the present and future plant breeding programmes and the urgency for their conservation.

The development of disease- and pest-resistant cultivars of wheat, rice and corn, which is responsible for the success of green revolution, is due to infiltration of genes from wild relatives to the high-yielding hybrid genotypes. Further, the wild relatives of crops contain productivity promoting gene assemblies, and hence constitute yield-promoting germplasm (Frankel & Brown, 1984). In fact, the entire research strategy for the agricultural transformation of the marginal lands (in contrast to fertile soils) centres around the development of crop varieties characterized by : (i) drought resistance; (ii) ability to thrive in soils that are excessively saline, alkaline or acidic; (iii) tolerance to toxic amounts of aluminium and (iv) ability to grow in soils that are deficient in phosphorus and nitrogen. The marginal lands are more extensive than the fertile zones, and even a modest increase in crop yield would benefit one billion people who eke out a living in environments that produce meagre yields because of ecological limitations (Plucknett & Smith, 1982).

The work on tailoring of crops to adverse water and soil conditions utilizing the gene pools of land races, and of weedy and wild relatives of crop species has already been initiated. Using the germplasm available in gene banks, the International Agricultural Research Centre's Institutes have already developed rice varieties that are tolerant to saline soils, that can sustain flood waters, and that can be grown in acidic soils, and in soils with low nitrogen levels, and in rain-fed land; wheat varieties that are tolerant to drought and salinity; and *Triticale* varieties that are grown in highly leached soils which contain huge amounts of aluminium (Silva, 1976; Khush, 1977; CIAT, 1980; Epstein *et al.*, 1980; IARI, 1980; Singh, 1980; CIMMYT, 1981; IRRI, 1981; Plucknett & Smith, 1982; Plucknett *et al.*, 1983).

The wild species have also been utilized in the improvement of crops such as cotton, tobacco, sugarcane, potato and corn (Stalker, 1980). The development of high lysine corn and sorghum varieties by utilizing gene pools of land races exemplify how important the germplasm is in crop improvement programmes. This is further evident by the fact that the 21st century agricultural strategies include the transfer of genes that are tolerant to adverse water and soil conditions, of genes that are resistant to diseases and pests, of genes that control high nutritive quality, and of genes that influence useful agronomic traits from wild relatives to crop varieties by both conventional plant breeding and recombinant DNA technology (Brady, 1982; Swaminathan, 1982).

The basis for the utilization of gene pools in the plant improvement programmes rests upon the unique features of the germplasm : (i) each gene pool contains a gene or a group of genes that may or may not exist elsewhere; (ii) the highly integrated system of genetic and environmental balance of the population structure; (iii) germplasm represents the evolutionary product of natural and artificial selections of millions of years; and (iv) the germplasm has served as conservatories of heredities of plant resources. Furthermore, the wild species closely related to the cultivated plants are important as occasional and natural genetic contributors to crops and also as possible progenitors of the economic species. Consequently, the understanding of the origin and evolution of crop plants serves as an evolutionary road map, which can be used as an aid in the transfer of a desired gene from an ancestral wild species into the cultivar by hybridization (Sears, 1956; Chang *et al.*, 1972; Rick, 1977, 1979; Feldman & Sears, 1981).

GENETIC RESOURCES AS NOVEL AND NEW CROPS

The gene pools not only constitute additional genetic resources for the future improvement of crop plants and forest trees, but also new and novel plants of potential use in agriculture, forestry, medicine and industry. As Vietmeyer (1986) pointed out "to help feed, clothe, and house an increasing population, to make marginal lands more productive, to meet challenging resource needs, to reforest the devasted tropics, we need a revitalised worldwide investigation of little-known plant species. Such an effort would expand our agricultural resource base and ease our dangerous dependence on a relatively handful of crops. It would build a more stable food supply for drought-stricken Africa and other parts of the world, and it would reclothe many of the barren lands where erosion now threatens disaster. Some plants that are now virtually unknown are likely to become mainstays of international agriculture and industry"

Throughout man's history, some 3000 plant species have been used for food, but, today, most of the world's food comes from 20 or 30 species. In other words, the vast majority of the world's edible plants have yet to be developed to their potential. For example, the pesibaye palm *(Guilielma gasipaes)* of Central America produces fruits which contain carbohydrates, protein, oil, minerals and vitamins in nearly perfect proportions for the human diet. These fruits constitute probably the most nutritionally balanced of all foods. Similarly, the grain amaranths *(Amaranths)* the tuberous legumes *(Apios americana* and *Pachyrhizus)*, the bambara groundnut *(Vigna subterranea)* and the winged bean *(Psophocarpus tetragonolobus)* are all little known plants of potential food value. There are about 3000 different fruit species, but only four — bananas, pineapple, papaya and mango — have been developed into major crops. Solanaceous *(Solanum quitoense* and *Cyphomandra betacea)* and annonaceous fruits *(Annona muricata, A. squamosa* and *A. cherimola)* and Kiwi fruit *(Actinidia chinensis)* are potential fruit crops. *Leucaena leucocephala, Acacia mangium, Mimosa scabrella, Calliandra, Indigofera* and *Desmodium* are promising legumes for combating the devastating tropical deforestation — one of the most pressing and difficult environmental problems in the world.

Simmondsia chinensis — a new crop which substitutes not only sperm whale oil but also used for the greening of deserts

— is a new crop for semiarid and arid regions of the earth (Benzioni & Dumstone, 1986). A variety of new crops *(Lesquerella* and *Grindelia)*, which yield industrial raw materials, can be grown in arid and semiarid regions. A host of higher plants *(Melia, Artemisia, Chrysanthemum, Parthenium argentium, Cucurbita foetidissima, Crambe, Hibiscus cannabinus, Cuphea, Vinca rosea* and several others) produce economically important organic compounds such as oils, resins, tannins, natural rubber, gums, waxes, dyes, flavours and fragrances, pharmaceuticals and pesticides; many species have never been described, much less surveyed for chemicals or biologically active constituents, and new sources of commercially valuable materials remain to be discovered (Hinman, 1986). These resources yield biologically active plant-derived chemicals which can be expected to play an increasingly significant role in the commercial development of new products for regulation of plant growth and for insect and weed controls.

GENETIC RESOURCES AS RAW MATERIALS FOR BIOTECHNOLOGY

The genetic resources also serve as raw materials for tomorrow's biotechnology. This can be exemplified by the production of sweet tasting protein, which is a low-caloric substitute for sugar, in genetically engineered yeast and *E. coli* (Edens *et al.*, 1984; Edens & Vanderwel, 1985). *Thaumatococcus danielli* is a member of Marantacea and is confined to W. Africa; it produces sweet tasting arillate fruits. The protein responsible for the sweet taste is Thaumatin which is found in the aril of fruits; it has flavouring enhancement property; its mRNA was isolated and the cDNA was also made. The cDNA was used to isolate the Thaumatin gene and the gene is cloned into yeast as well as in *E. coli.* The gene was expressed in yeast; the thaumatin (the trade name 'Talin') which is now manufactured on a commercial scale through genetically engineered yeast, is used in chewing gum, pharmaceuticals and sweet products.

Sunflower oil has a ~~temperature-labile~~ system and shows changes in the proportion of linoleic and oleic glycerides produced, which depend on the temperature experienced during seed maturation. Australian scientists have discovered a gene that confers a high degree of temperature stability in the sunflower system among the gene pools. The genetic engineering of the sunflower with this gene enable to produce sunflower genotypes in which the desirable lineolic remains high (70 per cent of the total triglycerides) over large range of temperatures.

Tissue culture technology can also be used to produce an array of secondary metabolites from those genetic resources which are not yet exploited fully.

The genetic resources are also important for the construction of new variability by gene splicing techniques and mutagenesis (Peacock, 1984).

LOSS OF GENETIC RESOURCES

The bulk of the gene pools of the wild species are found in the tropical rainforests which rank among the most complex and diverse ecosystems. The tropical forests are the most diverse of the earth's ecosystems. for example: In Peruvian Amazon rainforest, a plot no bigger than a hectare contains 41,000 species, including 12,000 beetles. In 10 separate 1-hectare plots of Borneo, as many as 700 species of trees are counted. From a single tree as many as 43 species of ants belonging to 26 genera are identified (Lewin, 1986a). Although the rainforests constitute only seven percent of the earth's land surface, they contain 40 to 50 percent of the planet's 5-10 million species of biota and 1,00,000 species of the planet's 2,50,000 higher plant species (Myers, 1981). There is some 80 kg of vegetation per square meter in these forests. As much as 80 percent of the world's insects live in the tropical forest. These rainforests harbour vast reservoirs of genetic material that could serve 'pragmatic purposes of mankind' The plant species of rainforests have already made innumerable contributions to modern agriculture, medicine and industry; a host of new foods are available from these ecosystems; the tropical trees produce many different hydrocarbons, opening up the possibility of 'growing gasoline' in the form of petroleum plantations (Calvin, 1978, 1985; Nat. Acad. Sci., 1975, 1980). In fact, the tropics may be the jewel in the crown of biological diversity, but they are also largely unknown and unrecorded by science.

The importance of tropical rainforests in plant biological studies is further evident from the comments of Tomlinson and Raven (1978) who write "Any comparative study of plant form or structure is based on incomplete premises if it does not take into consideration the total range of natural variability in plants, *i.e.* including the enormous diversity of plant life in the tropics. Any physiological mechanism or ecological response has been analysed insufficiently if it does not consider how these mechanisms or responses are mediated in tropical climates and especially in the non-seasonal climates of the lowland tropics. Any evolutionary idea has been incompletely scrutinised if it has not been tested against tropical examples. Any generalization of plant population biology must apply to the frequently distinctive composition of tropical forests." Nevertheless tropical rainforests are less known to science than other ecosystems. For example, of the myriads of species inhabiting the rainforests, a vast majority of them have yet to be documented, and only one percent of species has been intensively screened for their potentially useful benefits to human society. The precious reservoirs of animals and plants are being destroyed at a rate of between 50,000 and 2,00,000 square kilometers each year. The rainforest disappears by 2135 A.D. at which time the global population reaches plateau at 11 billion (Lewin, 1986). In the words of Myers (1981) ... this will represent a biological debacle to surpass all others that have occurred since life first emerged 3.6 billion years ago. Not only will it bring to an end many of the greatest concentrations of species and many of the most diverse ecosystems on earth, but also it will precipitate a basic shift in some of the earth's most dynamic evolutionary processes' If the tropical deforestation will continue at the current rates, 50 percent species loss would be inevitable; this 50 percent extinction would be closely comparable with the mass extinction of 65 million years ago, during which the dinosaurs finally disappear together with 60 to 80 percent of rest of the world's species. In contrast to earlier extinctions, the present losses involve large numbers of plant species and the agent causing extinction is human intervention.

CONSERVATION OF GENETIC RESOURCES

The only way to avert the mass extinction without asteroids in the present geological era — one of the serious global crisis created by human intervention in, the biosphere, and a serious threat to human civilisation — is the conservation. In fact, the World Conservation Strategy Document (IUCN, 1980) has been devised with this objective. While launching the World Conservation Strategy in India (on March 6, 1980), the late Prime Minister Mrs Indira Gandhi remarked "the interest in conservation is not sentimental one but the rediscovery of a truth well-known to our sages." In the words of Khoshoo (1986) 'the conservation of biological diversity is among the most important and at the same time, least appreciated challenges of the present and immediate future. E. O. Wilson of Harvard University (Lewin,1986a) writes "we are locked into a race. We must hurry to acquire the knowledge on which a wise policy of conservation and development can be based for centuries to come, before opportunities of unimaginable magnitude are closed forever" The newly formed Society in USA — Club of Earth — also echoed the threat to civilisation due to species losses and the scant attention paid to the conservation biology, particularly in tropics. Throughout the world, several conservation groups have been pressing for the protection of biological diversity, particularly in tropics (Mares, 1986). On the problems of conservation in tropics, M. Robinson of National Zoological Park, Washington (Lewin, 1986) rightly pointed out "the problems are not due to ignorance and stupidity. The problems derive from the poverty of the poor and the greed of the rich" The document 'Tropical Forests: A Call for Action prepared by an International Task Force Convened by the World Resources Institute, The World Bank, and the United Nations Development Programme 1985 is a 'path-breaking' report that recognizes the great challenges posed by tropical deforestation while offering a positive and practical strategy for its amelioration. *Tropical Forests: A Call for Action* is not just about trees, but about people and their prospects for a better life. We fervently hope that this report will help, stimulate financial and policy commitments from developing and industrial country leaders, development assistance agencies and the private sector for a greatly expanded and coordinated global effort to combat deforestation (WRI, 1985).. In October 1985, the Prime Minister of India, Rajiv Gandhi gave a memorandum to the Secretary General of the United Nations on behalf of thirty-five world leaders drawn from both developing and developed countries. He stated "Mankind has many challenges: to obtain a lasting peace between nations; to preserve the quality of the environment, to conserve natural resources at sustainable level, to advance the economic and social progress of the less developed nations, and to stabilize population growth" (Swaminathan, 1986).

There are two ways of conserving genetic resources, *in situ* (in nature reserves) and *ex situ* (in botanic gardens and gene banks).

The *ex situ* conservation of crop genetic resources has been made substantial progress. The International Board for Plant Genetic Resources (IBPGR) — one of the 13 International Agricultural Research Centres of the Consultative Group on International Agricultural Research with its regional centres in different countries is largely responsible for the collection, evaluation and conservation of crop genetic resources. The IBPGR also established a global network of 30 gene banks in 24 countries (IBPGR 1983).

In India, the National Bureau of Plant Genetic Resources with its Regional Centres scattered throughout the country is concerned with the *ex situ* conservation of crop genetic resources. Some of the approaches followed for *ex situ* conservation are seed banks, pollen storage, tissue culture, and gene and genome libraries.

The 600 Botanical Gardens around the world are also associated with *ex situ* conservation; a recent International Conference on the Botanic Gardens and World Conservation Strategy (IUCN, 1986) passed a series of resolutions and emphasized to adopt and implement a *Botanic Gardens Conservation Strategy*. The Botanical Survey of India with its network of Botanic Gardens is also playing a significant role in the *ex situ* conservation of plant genetic resources.

The *in situ* conservation is mostly in the form of Ecological Preserves, Nature Reserves, National Parks, Wildlife Sanctuaries, *in situ* Gene Banks and Biosphere Reserves. There are about 243 Biosphere Reserves in the International network comprising some 65 countries. In India there are 44 National Parks and 207 Sanctuaries, besides the 13 proposed Biosphere Reserves; in Meghalaya a Citrus gene sanctuary is also established.

The World Wildlife Fund (WWF) and the International Union for Conservation of Nature and Natural Resources (IUCN) are actively engaged in the Conservation of Plant Genetic Resources (The IUCN/WWF Plants Conservation Programme 1984-85). The Man and Biosphere (MAB) — a World Wide Programme of International Scientific Cooperation is also concerned with the conservation of plant genetic resources. The International Union of Forestry Research Organisations (IUFRO) is concerned with the conservation of forest genetic resources. FAO and UNESCO are also contributing to the protection of biodiversity. The Tropical Forests: A Call for Action envisaged an expenditure of $ 5320 million dollars for a period of five years in some 53 countries for saving the tropical forests. All the major tropical timber producing and consuming nations agreed to put into operation "the International Tropical Timber Agreement" which is aimed at sustainable utilization and conservation of tropical forests and their genetic resources and at maintaining the ecological balance; the headquarter for this is located at Yokohama in Japan (Anderson, 1986). The Convention of International Trade in Endangered Species (CITES) is also aimed at the protection of genetic resources.

The Department of Environment, Forests and Wildlife with Botanical Survey of India as its nodal centre is directly concerned with the protection and sustainable utilization of plant genetic resources. The Forest Conservation Act 1980 and the Environmental Protection Act 1986 are two important legislations of the Government of India dealing with the conservation strategies.

PATENTS FOR GENETIC RESOURCES

Third World Countries struggling to protect their genetic resources have been facing two problematical issues: (i) the rapidly diminishing genetic endowment due to financial crisis, the need to produce more food to feed the teeming millions and to mobilize more resources, particularly the forest resources for export to earn the scarce foreign exchange; and (ii) the escalating conflict among U.S.A. and other Industrialised Nations, Third World and Translational Corporations for the Control over the World's germplasm.

The global rift over genes is virtually an International 'seed war' that threatens to dry up the sources of rare germplasm materials. This is the conflict between the developing countries located mostly in Southern Hemisphere, which are blessed with great biological diversity; and the industrial countries of Northern Hemisphere, where genetic engineering revolution is based. The northern nations depend on southern ones for new plant materials needed for the improvement of the crops, because they themselves are gene poor.

In the current system developing countries contribute their germplasm resources to industrialized countries, from which multinational corporations can create new varieties by which they can dominate the trade in genetic material. As the private sector gains control over the biological reserves, the industrialized nations are asserting a new form of economic control — this time over planet's gene pools (Perlas & Rifkin, 1986). Pat Mooney — a consultant to Third World Countries on the germplasm issue rightly comments "The South has been an unwitting raw material supplier to [the new biotech companies and multinational corporation which] use Third World germplasm to develop commercial seed, which is sold back to developing countries at higher prices"

In the UN meetings over the years, Southern Hemisphere Nations have spoken out against what they perceive as a new and insidious form of colonialism and they are beginning to mobilize in opposition. In 1983, as a result of these International debates, the UN, FAO passed a resolution launching an International Undertaking on Plant Genetic Resources. The FAO also established a commission on Plant Genetic Resources, which was to examine FAO policies and activities related to plant resources and recommend ways of improving germplasm management. The FAO's Commission also established an agenda for the next FAO meeting in 1987. Agenda items included a close look at the legal arrangements governing ownership of gene bank collections, and scrutiny of existing plant patent laws and their impact on the international exchange of germplasm.

Clearly, a new geopolitical struggle is taking shape. In the decades to come, southern and northern countries are going to lock horns in a fierce and protracted battle over the control of gene pools. The genetic endowment of the earth should be treated as the common heritage of all nations. Such a view should definitely contribute to the prevention of a potentially dangerous International conflict. But at the same time there should be measures to reverse the raw material supply role of southern countries.

However, the question — who shall inherit the seeds of Earth — yet to be answered.

CONCLUSION

The growing demand for genetic resources in agriculture and the emerging applications of biotechnologies suggest that elusive values will come into sharper economic focus in the years ahead. Evolution has progressed unmanaged for 3.5 billion years, but its future path is certain to be moulded by mankind. Consequently, conservation of plant genetic resources for posterity is our evolutionary responsibility.

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